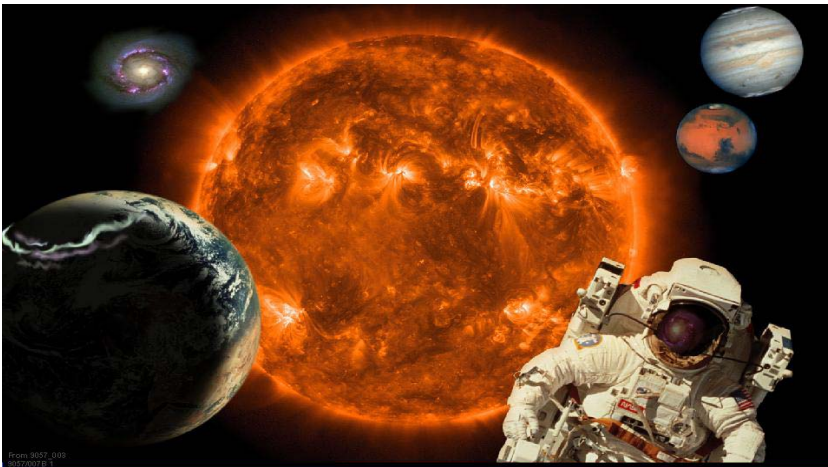


Living With a Star Program Overview



***Dana A. Brewer
SET-2 Requirements Workshop
September 11, 2003***

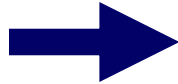
The Sun & Earth Are a Connected System

Variable Star



Interacting

- ***Magnetic fields***
- ***Plasmas***
- ***Energetic particles***



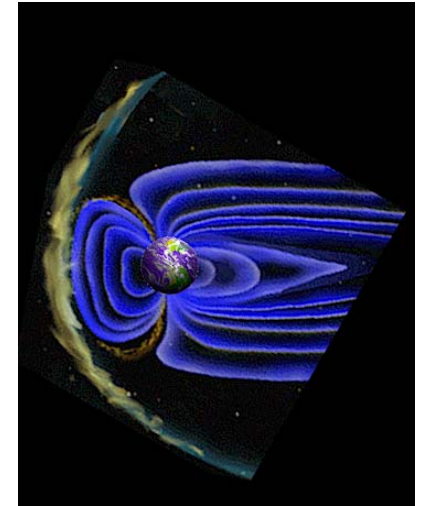
Varying

- ***Radiation***
- ***Solar wind***
- ***Energetic particles***

Interacting

- ***Solar wind***
- ***Energetic particles***

Earth



Interacting

- ***Magnetic fields***
- ***Atmosphere***
- ***Plasmas***
- ***Energetic particles***

QUESTIONS:

- ***How and why does the Sun vary?***
- ***How does the Earth respond?***
- ***What are the impacts to humanity?***

Living with a Star (LWS) Program Science Research to Reduce Impacts of Solar Variability (or Space Weather)

Human Radiation Exposure

- Space Station
- Space Exploration
- High Altitude Flight
- Space Utilization & Colonization



© 1998 Geoff Sobering

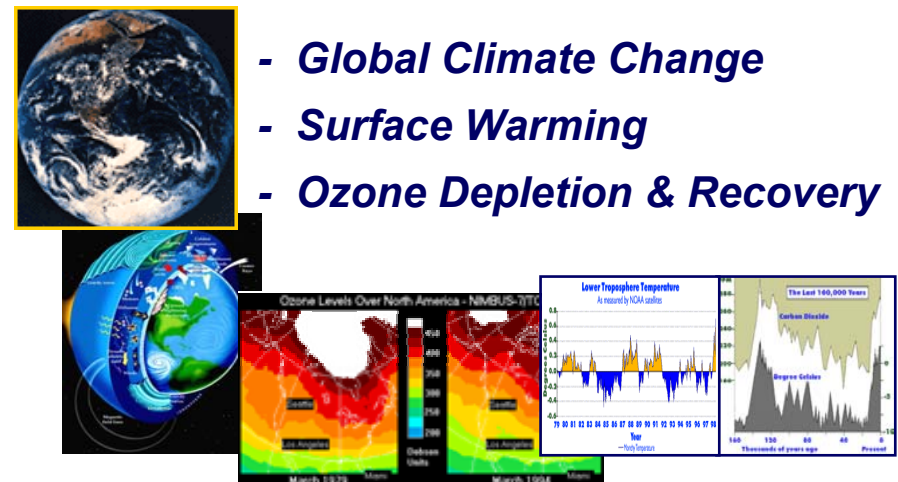
Impacts on Technology

- Space Systems
- Communication & Navigation
- Ground Systems



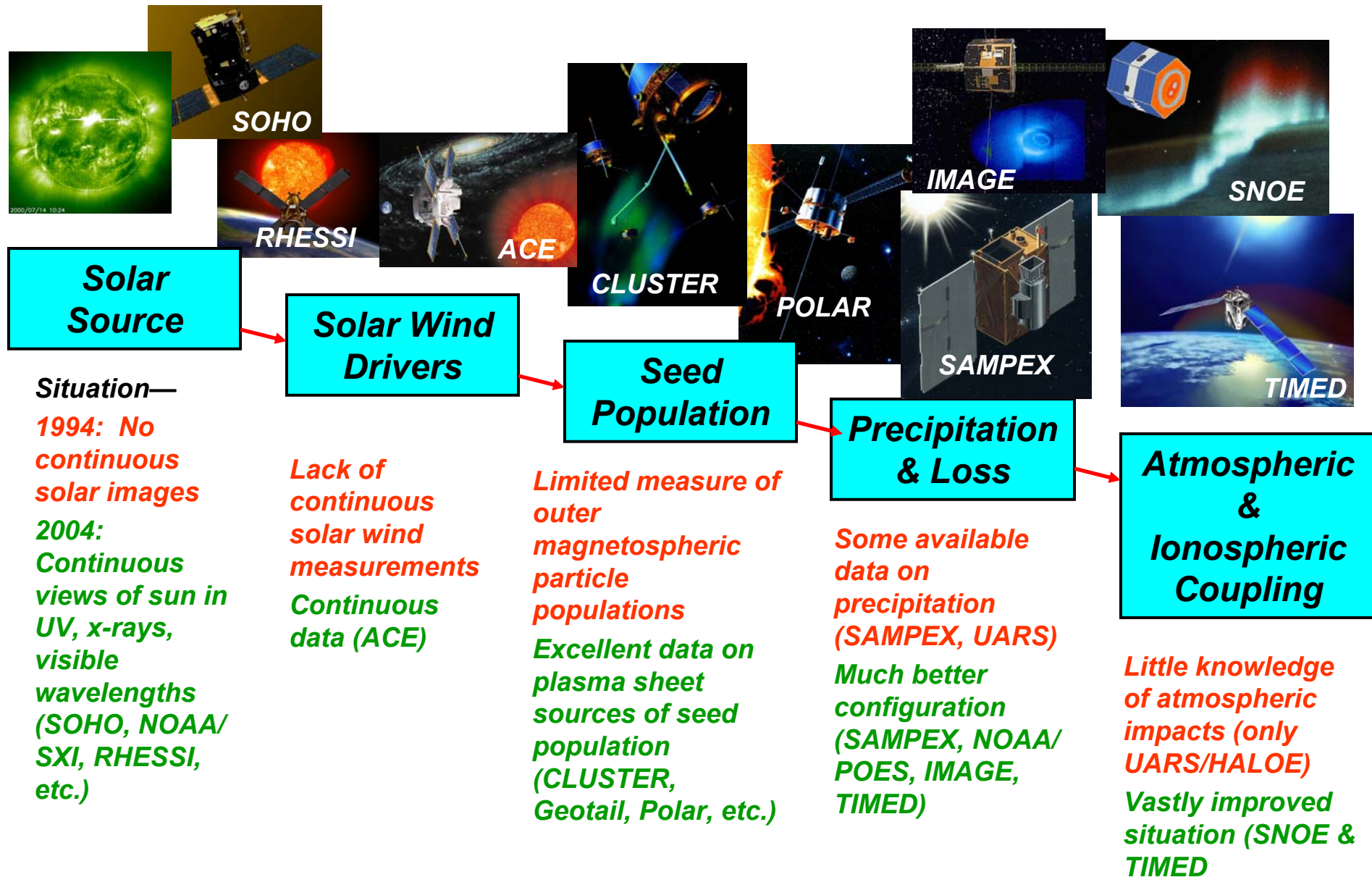
Impacts on Life & Society

- Global Climate Change
- Surface Warming
- Ozone Depletion & Recovery

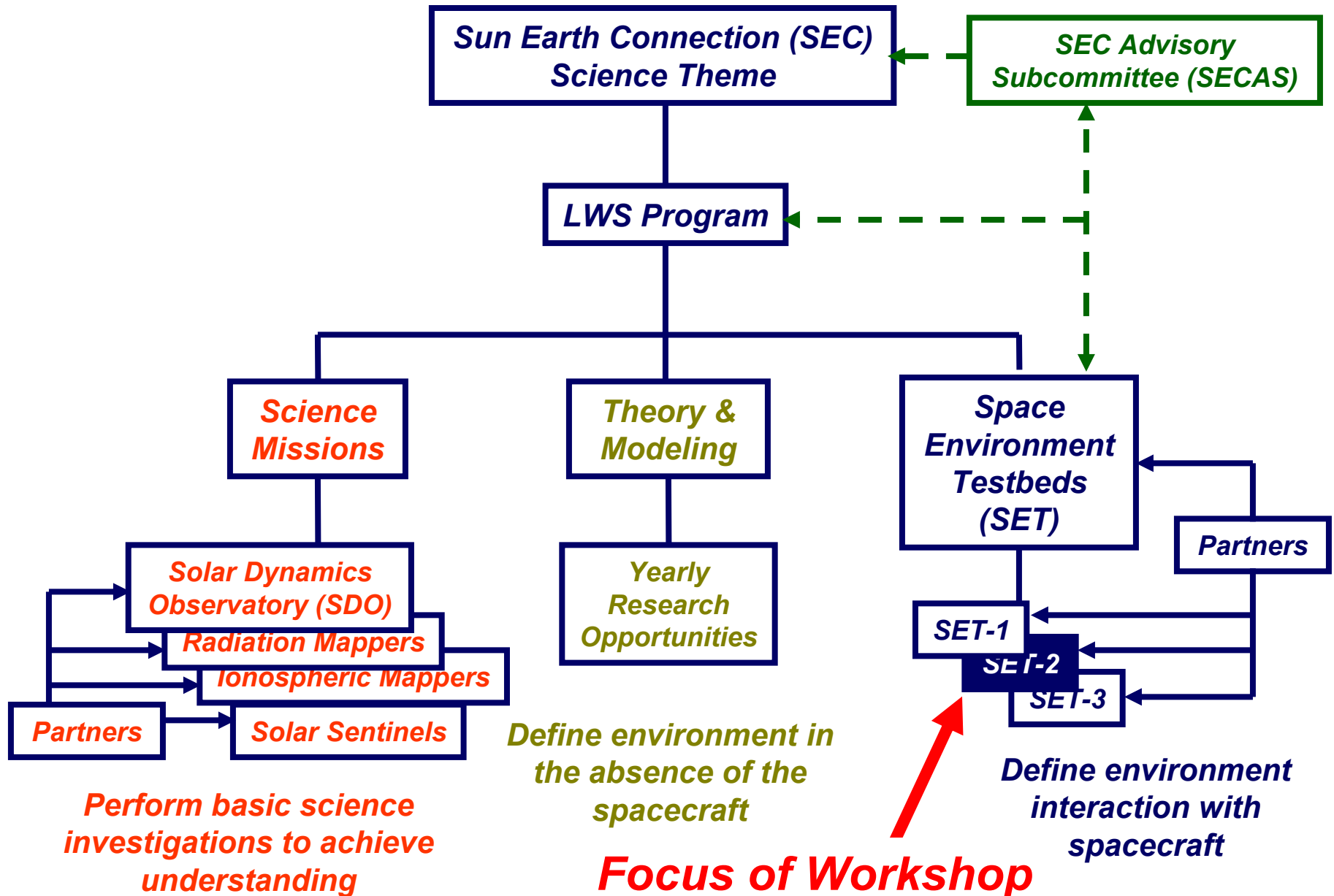


Studying the Solar-Terrestrial Particle Chain

1994 vs. 2004



Living With a Star (LWS) Program Architecture



Living With a Star Science Missions

Objective

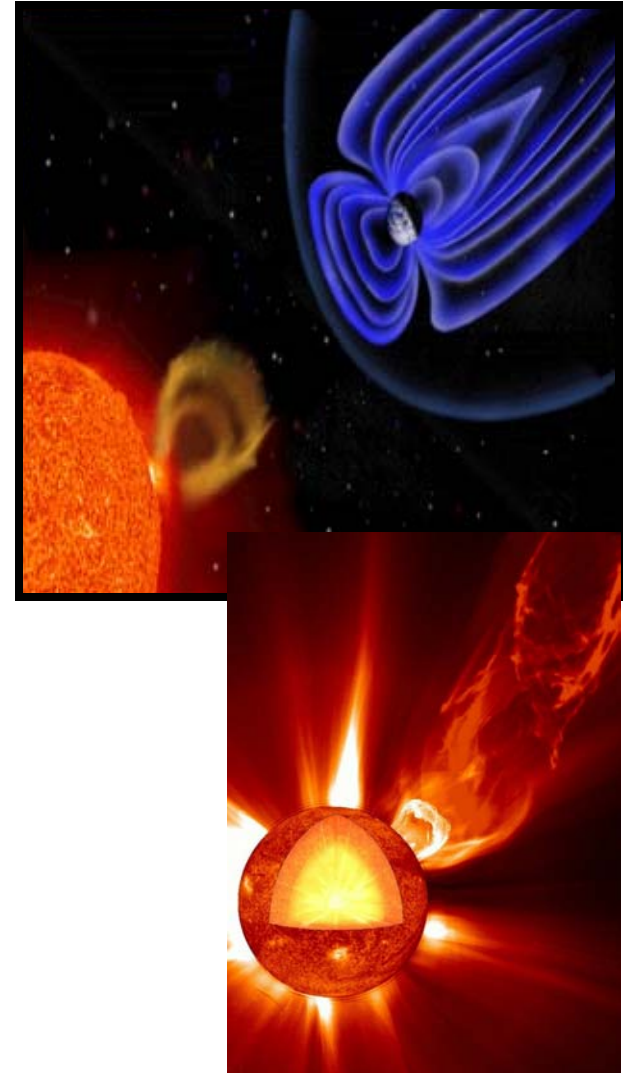
Perform investigations in space to understand solar variability & its effects leading to a reliable predictive capability of solar variability (i.e., space weather)

Approach

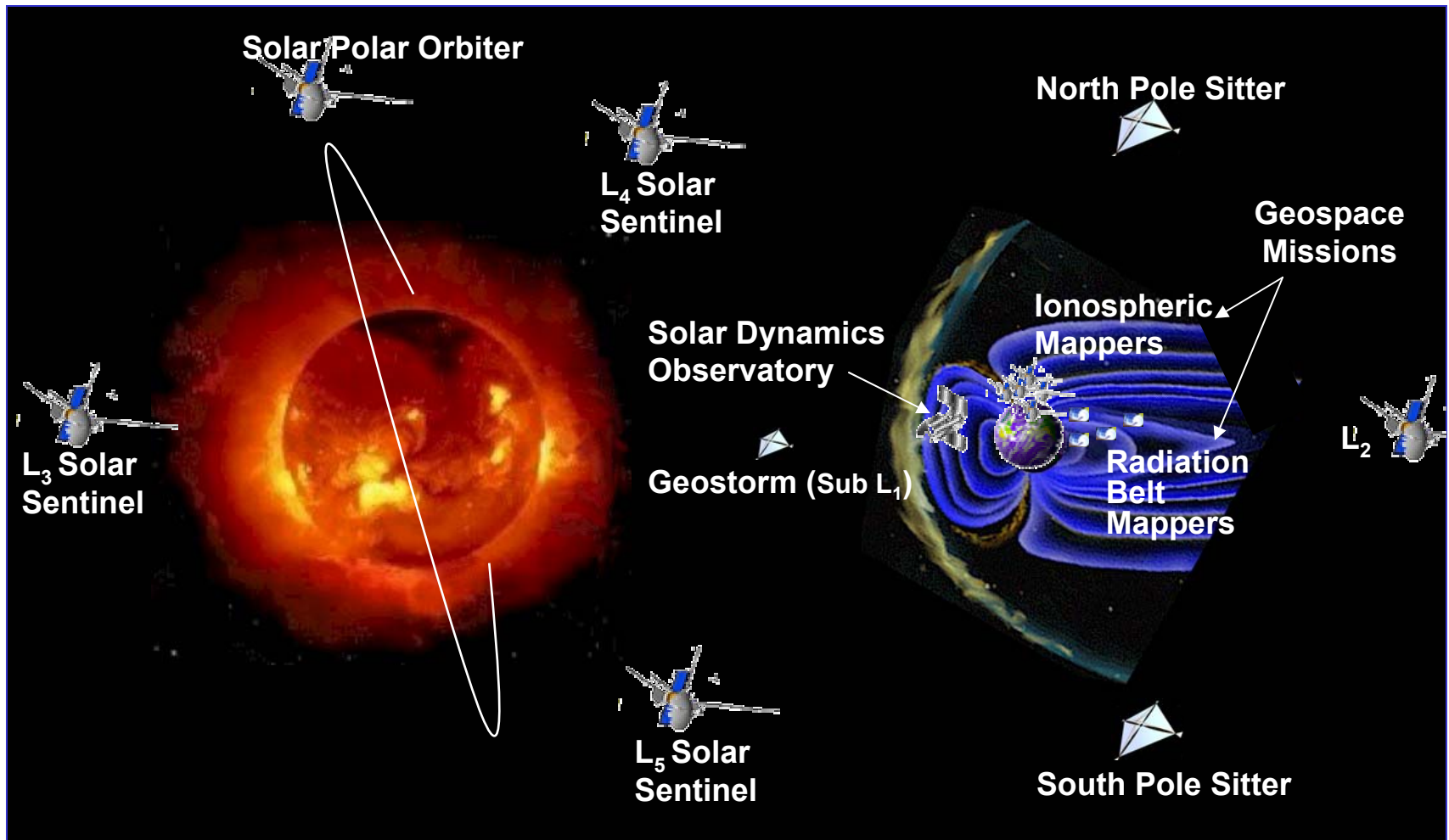
- Perform investigations on the interactions & variations of the particles, plasmas, & fields around the Sun & around the Earth***
- Perform investigations on the interactions & variations of the particles, atmospheres, & fields between the Sun & the Earth***
- Perform analysis to improve the description of the fundamental physical processes responsible for all the variations***

Scope

Solar atmosphere to Earth's ionosphere

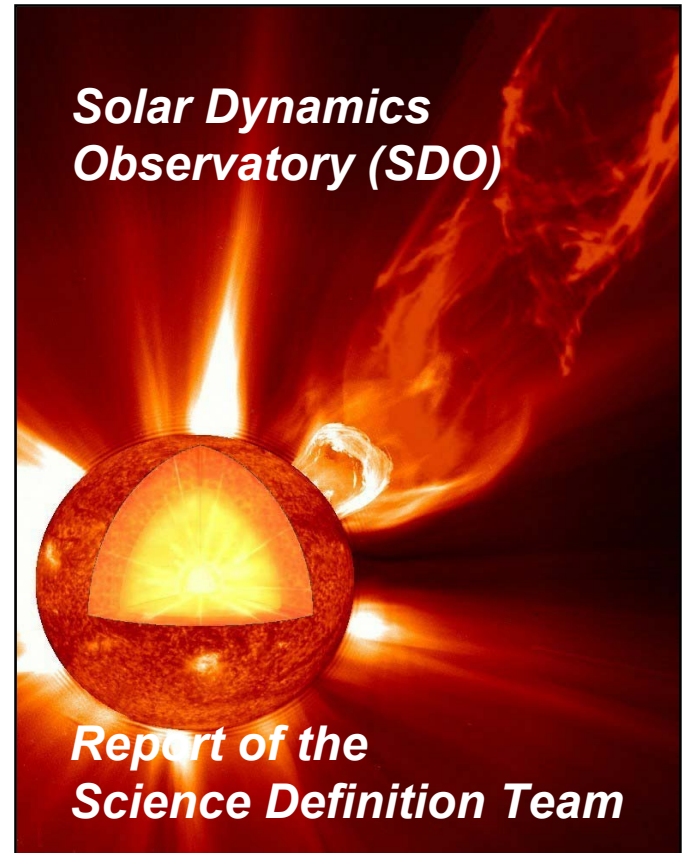


Living With a Star (LWS) Science Missions: A Network to Quantify the Sun-Earth Connected System



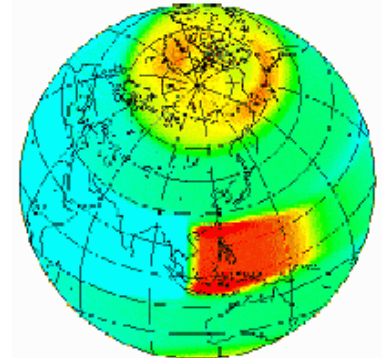
SDO Mission

- ***Focus areas***
 - *Mechanisms of solar variability on 3 timescales:*
 - ***The solar cycle***
 - ***Active region evolution***
 - ***Small-scale magnetic element interactions***
 - *3 sources of solar influence on global change and space weather:*
 - ***Irradiance variations***
 - ***Energetic particles and flares from CMEs***
 - ***Plasma disturbances from solar wind***
- ***2007 Launch, 5-year primary lifetime, Geosynchronous orbit***
- ***3 solar-pointed instruments***



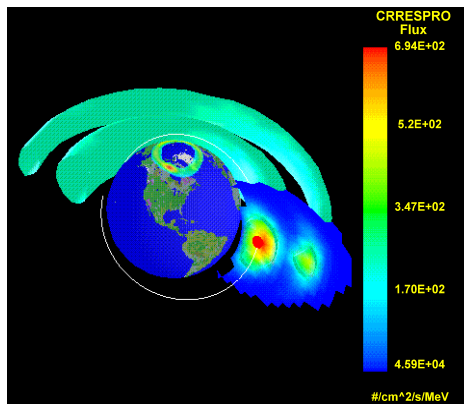
Geospace Missions

- **Geospace Mission Definition Team Report**
 - “The LWS Geospace Storm Investigations: Exploring the Extremes of Space Weather”
- **Ionosphere-Thermosphere Mappers**
 - Goal: Characterize and understand mid-latitude ionospheric variability & the irregularities that affect communications, navigation, & radar systems
 - LEO - 2 identical spacecraft - 450 km at 60° inclination separated by 10° to 20° local time

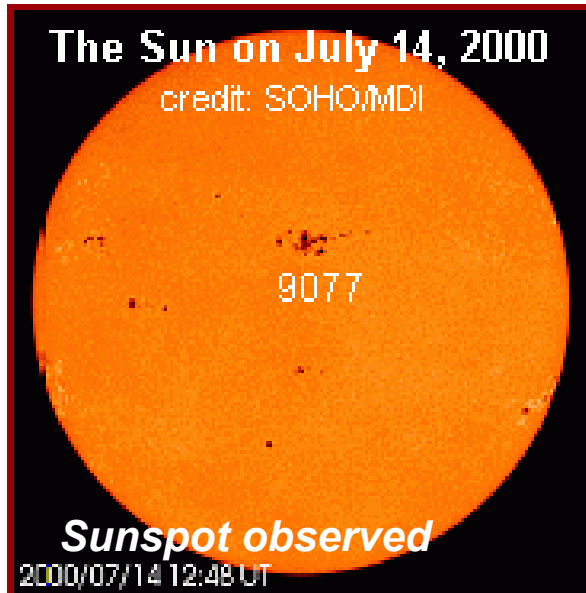


- **Radiation Belt Mappers**

- Goal: Characterize and understand the acceleration, global distribution, and variability of the radiation belt electrons and ions
- HEO - 2 different spacecraft proposed
 - 1 fully instrumented & 1 that excludes field and waves
 - 500 x 30,600 km, 12° inclination, different local times



Example: Using Multiple Missions As a System to Characterize the Bastille Day Event - An LWS Goal



What Happened:

***Evolving AR 9077
sunspot***

***Very high X-ray levels
detected at GOES***

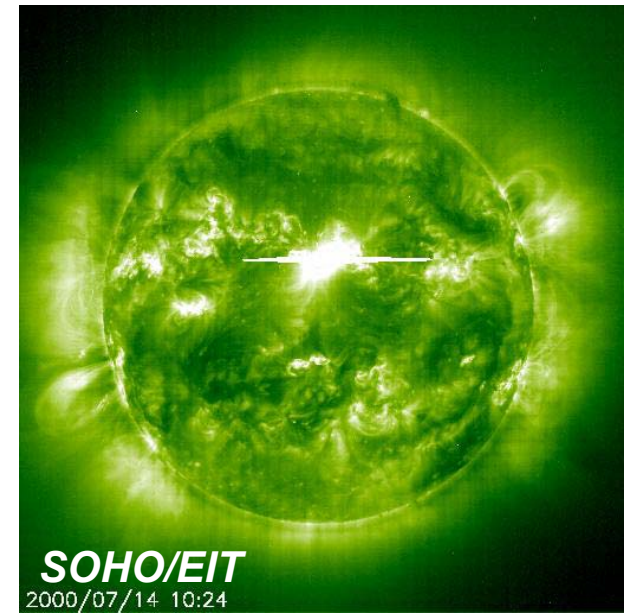
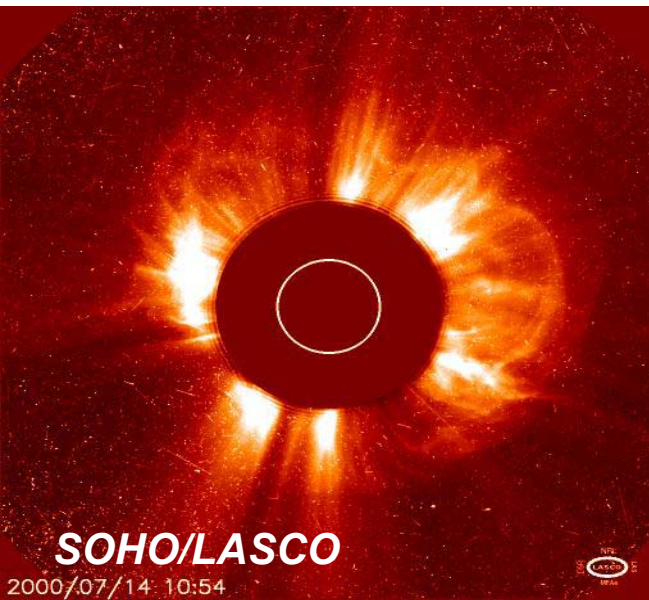
High Velocity CME

***Prompt detection of
solar energetic
particles at L1***

***Earth's response on
7/15***



***SOHO/MDI observes X5 flare at
10:19 UT on 7/14/00***



Living With a Star Theory & Modeling

Objective

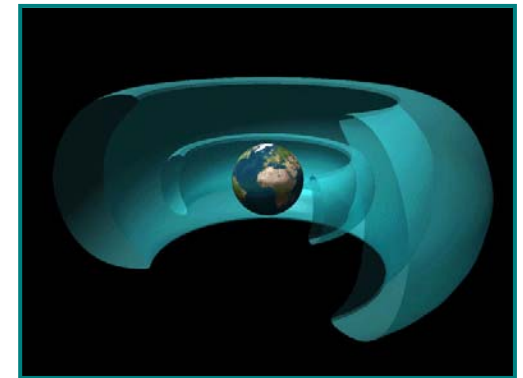
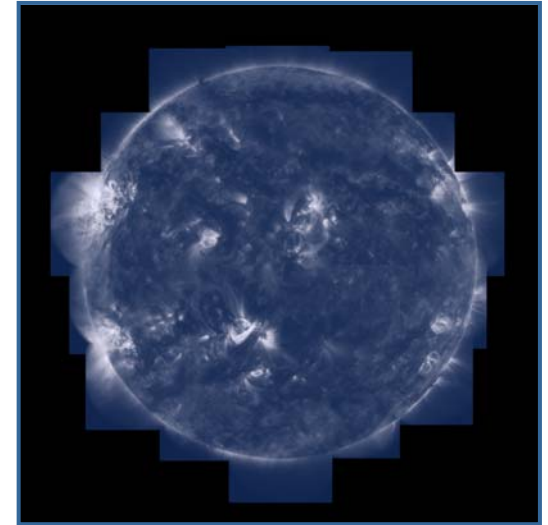
Perform research on the ground to refine the understanding of space weather & the role of solar variability in terrestrial climate change

Approach

- Improve the description of the physics of the interactions & variations of the particles, plasmas, & fields around the Sun, around the Earth, & between the Sun & the Earth***
- Improve understanding of the effects of solar variability on long-term climate change***
- Improve the environment specification models & predictive capability***

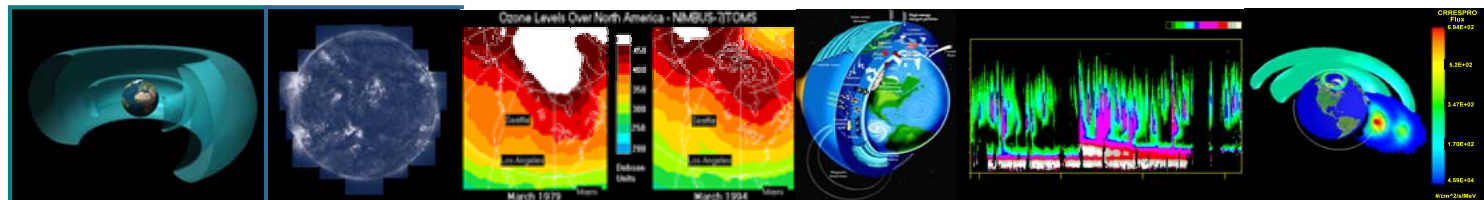
Scope

Solar atmosphere to Earth's ionosphere



Theory & Modeling

- **Description: Ground-based analyses that are performed using data from past and present space missions**
- **Types of investigations**
 - Develop new instrument techniques, models, and concepts for investigating solar & geospace disturbances
 - Enhance the understanding of the role of solar influences on terrestrial global climate
 - Improve scientific knowledge of space environment conditions & variations over the solar cycle
 - Develop models & concepts for the infrastructure of future LWS missions
- **Yearly Research Opportunities in Space Science (ROSS) NASA Research Announcements started in 2000**
 - 60 grants awarded in 2000 - 48 grants in 2001
 - Grants topics cover solar interior to Earth



Living With a Star Space Environment Testbeds (SET)

Objective

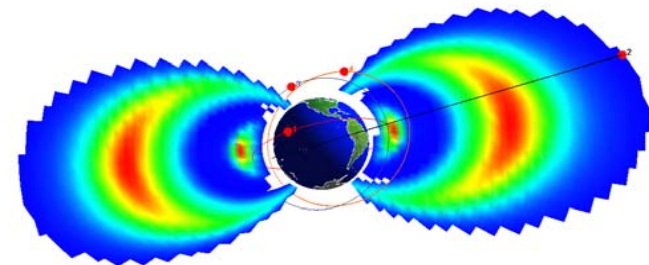
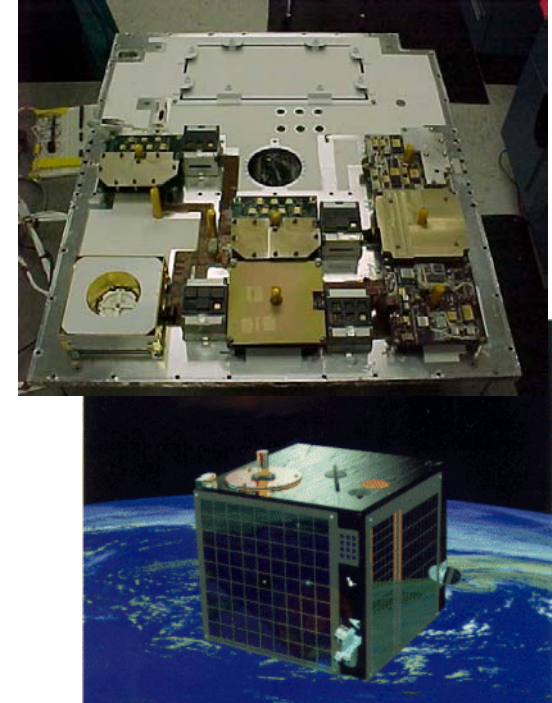
Improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design & operations

Approach

- ***Collect data in space to validate the performance of new technologies & instruments for LWS science missions***
- ***Collect data in space to validate new & existing ground test protocols for the effects of solar variability on emerging technologies***
- ***Develop & validate engineering environment models, tools, & databases for spacecraft design & operations***

Scope

Spacecraft hardware & design /operations tools whose performance changes with solar variability



Space Environment Testbeds (SETs): 2 Components With Competed Investigations

***NASA Research
Announcement
(NRA) 8-31: 8
Awards in 3/02***

***NRA 02-OSS-04
for SET-1
Investigations:
7 Selected for
Phase A***

SET Data Analysis Component:

- ***Models, tools, or databases that describe performance variations in space in the presence of a spacecraft that change due to solar variability***

SET Space Flight Component:

- ***Technology that requires space flight for performance characterization or validation***
- ***Technology for >1 mission***
- ***Technology whose performance changes due to the effects of solar variability***

Space Environment Testbeds

- ***Goal: Physics-based understanding of response of technological systems to solar varying space environments***
- ***Focus areas***
 - *Reduce environment uncertainty margins in spacecraft design*
 - *Reduce vulnerabilities of spacecraft & instruments to Space Weather*
 - *Transfer knowledge to aircraft and ground based technologies*
- ***Mission every 2 years: first testbed ready for integration in late 2005/early 2006***
 - *Mission destinations driven by experiments*
 - *Will have opportunities for contributed experiments*
- ***Support relevant experiments on non-SET carriers***
- ***Actively solicit partnering at all levels***
- ***Flight investigation NASA Research Announcement has 5 categories:***
 - *Characterization of the space environment*
 - *Materials*
 - *Detectors/sensors*
 - *Microelectronics used in space*
 - *Charging/discharging effects*

Requirements for SET-2 tasks in these categories will be developed in this workshop

LWS Timeline



- **Science Missions will be in place for next solar maximum.**
 - Space Weather Research Network (SDO, Solar Sentinels, Geospace)
 - SDO instruments selected, spacecraft design begun
 - Geospace Instrument AO in 2003
- **Theory & Modeling (aka Targeted Research & Technology)**
 - Yearly Research Opportunities in Space Science (ROSS) Announcement of Opportunity
 - Working Group meets to develop requirements
- **Space Environment Testbeds**
 - Products from 1st data mining awards available
 - Next data mining opportunity in ~2007
 - Launches on 2-year centers, first in 2005/2006
 - **SET-1 awards for Phase A in May 2003**
 - **Candidate requirements for SET-2**
 - *Developed in this workshop*
 - Other flights of opportunity possible

